A SYNOPSIS

OF A

COURSE OF LECTURES

ON THE

Elements of Historical Paleontology,

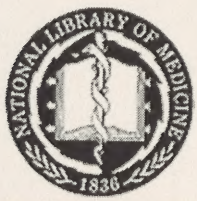
DELIVERED AT

CORNELL UNIVERSITY,

1885–86.

H. S. W.

ITHACA, N. Y.,
ANDRUS & CHURCH,
1886.



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Historical Paleontology.

1. Fossils :

[a]What are they? [b]From the geologist's point of view. [c]From the biologist's standpoint? [d]How considered in present course of lectures. [e]Importance of the study of fossils.

2. [a]Early knowledge of fossils. [b]In what respects imperfect. [c]When were fossils first clearly understood?

3. Cuvier :

[a]His observations in 1796. [b]His work of 1812–13, and its relation to the rise of the Science of Paleontology. [c]Why was he specially fitted to interpret fossils.

4. Who immediately followed Cuvier?

5. When and where the term Paleontology was first used?

6. The supposed nature of fossils before Cuvier.

7. What progress in science was essential before Paleontology could arise?

8. [a]What were the striking features of progress in the study of Natural History in the early years of this century? [b]Who were the leaders in the study of invertebrates? [c]Who developed the study of plants? [d]The results of their studies.

9. William Smith, 1816–20; his contribution to the Science.

10. Murchison & Sedgwick, 1839–55; their part.

11. The relation of stratigraphic geology to pure paleontology.

12. Paleontology :

[a]Its true scope. [b]The extent to which fossils are valuable in identifying strata and geological age. [c]Paleontology as an historical study. [d]Paleontology as a systematic science.

13. What preparatory study essential to its profitable pursuit?

14. Why separate it from Geology?

15. Why history of organism, and not ancient history?

16. Stratigraphy and Paleontology are intimately associated and should be studied together.

17. Organisms: what facts in regard to them of special interest to the paleontologist?

18. The chief topics to be considered in these lectures:

[a]The method of study. [b]The relative importance of the several kinds of facts presented. [c]Necessity of work outside the lecture-room. [d]Use of charts and specimens.

19. Text books; qualities demanded, where to be found.

20. The scientific use of generalizations *versus* the superficial treatment of science.

21. Geologic time:

[a]Its subdivisions, how determined? [b]Stratigraphical succession the fundamental criterion of length and order of time. [c]The classification of the strata forms the basis for the chronologic divisions.

22. [a]The system of nomenclature adopted by the International Congress. [b]How different from that in common use in America as illustrated in Dana's Manual.

23. Reason for recognizing nine chronologic divisions, corresponding nearly to the Periods of the international nomenclature.

24. Relative length of duration of the Periods; how determined?

25. Diagrammatic representation of the relation between the duration of the Periods and the progress in rank and variety of form of the organisms inhabiting the globe. (See p. 5.)

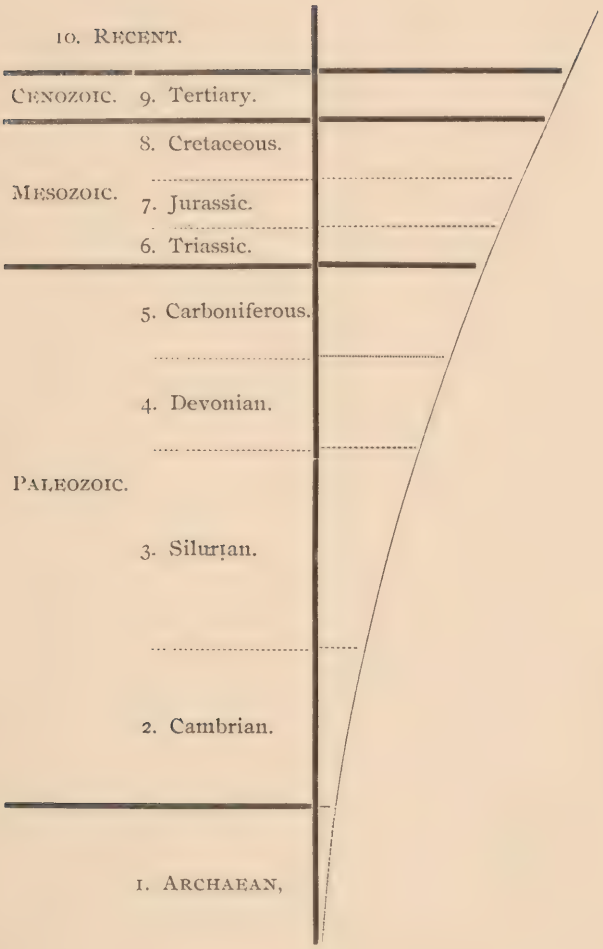
26. Usage of the terms Horizon, Zone, Stage, Group, Formation, Period, Age, Fauna, Flora.

27. Fossils:

[a]Lyell's definition. [b]Origin of the name. [c]Its later usage. [d]Examples of present usage. [e]Hard-parts of animals. [f]Classification (of C. A. White): (1) Fossils proper; (2) moulds (or internal or external impressions); (3) casts; (4) pseudomorphs. [g]The occasional use of the term "cast. [h]Crushing and distortion of fossils. [i]Metamorphism.

28. [a]Imperfection of the fossils, and of the record. [b]What do they represent, [c]and in what particulars is the historical record necessarily deficient?

29. The classes of the Animal Kingdom having fossil representatives. (See p. 6.)



DIAGRAM

Representing the relative length of the Geologic Periods, and the progress in the rank and variety of form of the organisms inhabiting the globe.

List of the Classes of the Animal Kingdom represented in the fossil state, with their Geologic Range.

PROTOZOA.

1. Rhizopoda.

COELENTERATA.

2. Spongia.
3. Actinozoa (=Anthozoa.)
4. Hydrozoa (=Polypomedusa.)

ECHINODERMATA.

5. Crinoidea.
6. Asteroidea.
7. Echinoidea.
8. Holothurioidea.

VERMES.

9. Annelida.

MOLLUSCOIDA.

10. Bryozoa(=Polyzoa.)
11. Brachiopoda.

MOLLUSCA.

12. Lamellibranchiata
13. Gastropoda.
14. Pteropoda.
15. Cephalopoda.

ARTHROPODA.

16. Crustacea.
17. Arachnoidea.
18. Myriapoda.
19. Insecta.

VERTEBRATA.

20. Pisces.
21. Amphibia.
22. Reptilia.
23. Aves.
24. Mammalia.

30. [a]Relation of habitat to the preservation of fossil remains. [b]Marine faunas. [c]Brackish water faunas. [d]Faunas and floras of land, and of fresh water.

31. Geographical distribution and provinces.

32. Geological range.

33. The relative completeness of the record for the several groups of organisms.

34. Special value of invertebrates for historical study.

35. Common and abundant forms as compared with rare and unique forms.

36. Facts worthy of particular note in regard to the organisms of each period: [a]Dominant forms. [b]First appearance or initiation of new types. [c]Decrease and extinction.

37. Geologic periods not marked off by sharp lines.

38. The importance of the Paleozic records in the study of the history of Organisms.

39. Most of the types of the Animal Kingdom begin in the Paleozoic era.

I, THE ARCHAEAN.

40. [a]Character of the rocks. [b]Thickness of the deposits in Canada. [c]How deposited, and present condition. [d]The names Archaean and Eozoic. [e]Sources of information in regard to the Archaean record.

41. Evidences of organic life:

[a]The structure and character of the rocks. [b]The limestones, their thickness and interpretation. [c]Graphite. [d]Iron ares. [e]Eozoon, its discoverer, when found, description, what it resembles, opinions as to its nature; theory as to its mode of preservation. [f]Other supposed organisms.

42. The supposed successors and the systematic relations of the Eozoon.

43. Foraminifera as limestone builders.

44. Variability and persistence of the characters of foraminifera.

45. Summary.

II, THE CAMBRIAN.

46. [a]The Cambrian system of Sedgwick. [b]The Primordia Zone and Fauna of Barrande. [c]The fauna and its limits. [d]The interpretation of the Cambrian of America (Walcott). [e]The grand cañon section and the Tonto group.

47. The two grand life-periods of the Paleozoic and their characteristics :

[a]Cambrian—Silurian ; abundance of Trilobites, Graptolites and Brachiopods, and absence of Vertebrates.

[b]Devonian—Carboniferous ; abundance and variety of Fishes and Amphibians, the disappearance of Graptolites and Trilobites, and finally the abundance of cryptogamous terrestrial life, or Flora.

48. The subdivision of the Cambro-Silurian.

49. The Murchison-Sedgwick controversy.

50. Limits of the Cambrian in America.

51. Paleontologic reasons for including part of the "Canadian Period" of Dana in the Cambrian.

52. The number of species recorded.

53. The typical British series, and the order of first appearance of the several classes and orders.

54. The Swedish section.

55. The section in Bohemia.

56. Relative prominence of the several classes in the Cambrian fauna : (1) Trilobites, (2) Brachiopods—the Tretenterate division, (3) Pteropoda, (4) Crustacea, other than Trilobites, (5) Cystidians, (6) then follow other Brachiopods, Sponges, Annelids, Gastropods, Graptolites, and Cephalopods.

57. Tabular view of the Animal Kingdom, (See Chart, and p. 6.) shows that all the branches of the Animal Kingdom were represented in the Cambrian fauna, except the Vertebrates.

58. Trilobites ; description of the structure of the Trilobite. (*Head* or *Carapace*, glabela, cheeks, eyes, facial suture, furrows, lobes, rostral shield, hypostoma ; *Thorax*, axis, pleura, facets, pleural groove, fulcra ; *Pygidium*, segments, limbs ; *Appendages*, (of Walcott), ventral membrane, intestinal canal, hypostoma, mouth, head appendages, thoracico-abdominal appendages, ambulatory legs, epipodites, branchia.)

59. Classification (of Salter) based on facial suture and eyes.

60. Early views about Trilobites.

61. Their geologic range.

62. Their position in the Animal Kingdom.

63. Range of the various orders of Crustacea.

64. The Annelida of the Cambrian.

65. Representative Trilobites of the Cambrian :

(1) Paradoxides, (2) Conocephalites, (3) Agnostus, and their respective families ; characteristics of 1 and 2, and differences ; same of Agnostus.

66. Historic laws deduced from the study of Trilobites.

67. Literature for fuller study of the subject.

68. Ostracoids and Phyllopods (Hymenocaris).

69. Mollusca and Molluscoida.

70. Brachiopoda :

[a]Tretenterata and Clistenterata. [b]Characters of the whole class, distinctions separating the two orders, (equilateral, bivalved, with or without peduncle, alimentary canal, complicated brachial apparatus, "blood channels," "pseudo hearts," numerous muscles). [c]Lingula and Discina still living. [d]Climax of the tretenterate Brachiopods. [e]Clistenterata begin in the genus Orthis.

71. Gastropoda—characters of. See genera Pleurotomaria, Euomphalus, Murchisonia, belong to the "Vegetarian Repentantia" of Lankester.

72. Free swiming Mollusca :

[a]Pteropods, represented by Theca and Conularia. [b]Cephalopods, by Orthoceras. [c]Lankester's views of the relations of these classes. [d]Their characters.

73. Lamellibranch's doubtfully represented.

74. Conclusions. The high character of the classes and the variety of forms presumptive evidence of previous life.

75. Absence of limestone may account for absence of some groups, viz., corals, etc.

76. Plants represented by Fucoids and Oldhamia.

77. Most of the classes represented by only a few traces, and begin in abundance in the Silurian.

78. Conspicuous law as to the rank of the early forms. The higher classes represented by their lower orders.

79. Prominent genera of the Cambrian: Paradoxides, Lingulella, Archaeocyathus, Obolella, Hymenocaris, Oldhamia, Slolithus, Sao.

80. Important genera beginning in the Cambrian are Orthis, Discina Pleurotomaria, Hypolithes (Theca), Lingula, Leperditia, Agnostus.

81. Some doubtful forms referred to Cystids, Crinoids, Orthoceras, and Graptolites.

III, THE SILURIAN.

82. Characteristics of the life of the System; great abundance and variety of marine life: rocks richly fossilferous.

83. Comparison between the history of the Trilobites and of the tretenterate Brachiopods.

84. The Silurian fauna:

[a]The great majority of its families and genera now extinct. [b]Thirty-one of the ninety-seven orders of fossil animals are known to have appeared before the close of the Silurian [c]Representatives of the majority of orders still living. [d]Mostly marine. [e]Dominant types—Mollusca and Brachiopods. [f]Highest types—Crustacea and Cephalopods. [g]New types initiated—Actinozoa, and before the close, traces of Vertebrates, and a land flora (Lycopods).

85. Recent discovery of Scorpions and Insects.

86. The Silurian system of Murchison.

87. Character of the rocks in Britain, in America. Maximum thickness.

88. Approximate number of species, (in 1868):

Brachiopds,	1600
Trilobites,	1600
Cephalopods,	1400
Gastropods	900
Lamellibranchs,	700
Actinozoa,	500
Echinodermata,	500
Polyzoa, Heteropoda, Entomostracans, each between	200 and 500

Other classes under 200 each, total about 10,000 species.

89. Graptolites, Cystids, and Entomostracans, form a conspicuous feature of the fauna.

90. Range of the classes of the Animal Kingdom, (see list, p. —).

91. Irregularity in the usage of the terms Branch, Class, Order.

92. Genus the most satisfactory unit of systematic classification.

93. Graptolites:

[a]Initiation in Cambrian; climax in Silurian; extinction near the close—(lower Devonian, Kayser.) [b]Classed near the Sertularians. [c]Found in "black" or "alum" shales or "slates." [d]Characters: polypary, "solid" axis, cellules, central disc, monoprionidian, diprionidian. [e]Dictyonema.

94. Actinozoa (corals):

[a]Range of the main types of the Silurian. (Chaetetes, Favosites, Halysites, Syringopora, Cyathophylum, and the Rugosa.) [b]Distinctive characters: walls, septae, tabulae, perforations, corallites, simple, massive, or compound, fossula, dissepiments. [c]Generic and specific differentia.

95. Echinodermata:

[a]Range of the principal types: Cystidians, Crinidians, Blastoids, Asteroids, Echinoids—(Archaeocidaris, Cidaris, and the irregular Echinoids.) [b]Typical characters, and their modifications and homologies in the several orders. [c]Essential characters, anatomical, and of the hard parts, mouth and oral end, aboral end and anus.

96. Typical arrangement of parts in a sea-urchin:

[a]Ambulacral rows, five pairs of two each. [b]Interambulacral plates, five rows of two pairs. [c]Apical disc, genital, ocular and anal plates.

97. Ambulacra:

[a]Ventral position of, in Asteroids.[b] confined to central disc in Ophiurans.

98. Crinoids:

[a]Stalk and calyx, openings all ventral and within base of arms. [b]Genetal system.

99. Cystidians—calyx irregular, arms wanting or rudimentary, valvular pyramid, hydrospires.

100. Blastoids—pseudoambulacra, regular plates few.

101. The generic and specific differentia of Crinoids and Cystids, and their classification.

102. Brachiopods:

[a]The two divisions Tretenterata and Clistenterata. [b]Range of the principal families: 1. Lingulidae; 2. Obolidae; 3. Craniidae; 4. Orthidae; 5. Strophomenidae; 6. Rhynchonellidae; 7. The genus Spirifera, and the spiral bearing Brachiopoda; 8. Productus and allied genera; 9. Terebratulidae. [c]Generic and specific differentia of Brachiopoda.

103. Law of the initiation of new forms, and the history of Brachiopoda.

104. Cephalopoda:

[a]The two orders, Tetrabranchiata and Dibranchiata. [b]Prominent characters of the class and of the orders. [c]The shell, its several parts, a chambered cone, septae, siphuncle, sutures, body chambers, aperture, sutures, lobes and saddles, (dorsal) external and (ventral) internal aspect of the coiled shells. [d]Subdivisions of Tetrabranchiata: 1. The Nautiloidea, (sub-order) mainly Paleozoic. 2. The Ammonoidea, mainly Mesozoic.

105. The Nautiloidea. For classification see Zittel.

[a]Fam. Nautilidae, proper, more conspicuous in later Paleozoic. [b]Fam. Orthoceratidae, a dominant Silurian family. [c]The characters and range of the genera: Nautilus, Lituites, Trochoceras, Clymenia, Orthoceras, Cyrtoceras, Phragmoceras, Gomphoceras, Endoceras. [d]Generic and specific differentia.

106. Remarks upon the studies of Hyatt and others, and the forms Orthoceran, Cyrtoceran, Gyroceran, and Nautilian, and their historical importance.

107. Order of initiation, and range in time of the several types; actual observed order, and order of prominence of each.

108. Trilobites:

[a]The differentia, generic and specific. [b]General law as to the initiation of new types. [c]Prominent Silurian genera: Acidaspis, Harpes, Calymene, Lichas, Asaphas, Bathyurus, Illaenus, Cheirurus.

109. Merostomata:

[a]Limulus, a modern representative. [b]The fossil sub-or-

ders: Eurypteria, its ordinal and sub-ordinal characters, and historical position. [c]Xiphosura, characters and range.

110. Tentaculites—a pelagic form; characters.

111. Lamellibranchs:

[a]Prominent Silurian genera: (Monomyaria) Avicula, Pterinea. [b](Dimyaria) Modiolopsis, Ctenodonta, Orthonota, Palearca.

112. Gastropods:

[a]Prominent genera: Murchisonia, Platyceras, Pleurotomaria.

113. Relative importance, in the Silurian, of the different types of Mollusca:

[a]Cephalopods, Pteropods, and Heteropods, the more dominant groups. [b]Prominence of pelagic forms, (as Bellerophon (?) Macluria, Ophileta, Theca, Conularia, Tentaculites.

114. Geographical differences in the range of species.

115. The Silurian system in different regions.

IV, THE DEVONIAN.

116. [a]The upper limit of Murchison's Silurian system, and [b]Conrad's application of it in New York, (1841), [c]Vanuxem's (1842) Erie division of the New York System, [d]Hall's usage, (1843–1846). [e]Lower limit of Devonian, (1846). [f]Oriskany sandstone, why the base of De Verneuil's Devonian, (1847)? [g]Oriskany, why the top of Hall's Silurian, (1859)? [h]Present usage.

117. The Devonian and the old Red Sandstone of English geologists.

118. These discussions illustrative of the importance of bringing lithologic, stratigraphic, and geographic facts to bear upon the interpretation of paleontologic history.

The marine invertebrate fauna of the Devonian.

119. Stony corals, (Actinozoa):

[a]Genera: Cyathophyllum, Zaphrentis, Favosites, etc. [b]Absence of the genus Halysites.

120. Hydrozoa:

[a]Dictyonema. [b]Monograptus recognized in lower Devonian in Prussia, by Kayser,

121. Crinoids :

[a]No great change in genera from the Silurian fauna. [b]Cystids wanting. [c]Blastoids few.

122. Mollusca and Molluscoida :

[a]An increase in the numbers of Gastropods and Lamellibranchs. [b]Cephalopods the most prominent group. [c]Brachiopods the most common of invertebrates, as they were in the Silurian.

123. Prominent genera of Cephalopoda : Orthoceras, Cyrtoceras, and Gomphoceras, and Goniatites and Clymenia, which were characteristic of some zones and are essentially Devonian types of Cephalopods.

124. Brachiopods :

[a]Prominent genera : Spirifera, Orthis, Strophomena, (Hall's genus Strophodonta). [b]The Productidae and Terebratulidae began to be conspicuous. [c]The genera Terebratula, Cryptonella and Productus are new.

125. Crustacea :

[a]Trilobites declining, prominent genera were Homalonotus, Phacops, Proetus, Bronteus. [b]Ostracoids abundant in some zones.

126. Vertebrates :

[a]The first age in which fishes were at all abundant, some traces of them below. [b]Placoderms the most conspicuous type.

127. Land plants :

[a]Lepidodendron. [b]Ferns. [c]Conifers. [d]Calamites.

128. The marine invertebrates with substantially the same families as in the Silurian.

129. The grand features of Devonian life are seen in its Vertebrates and Land Plants.

130. Vertebrate life of the Devonian. (See Newberry's views and classification, Paleontology of Ohio, Vol. I. ; Nicholson's Paleontology, Vol. 2. See also chart of classification and range prepared for the class).

[a]Fish—slight traces below the Devonian. [b]Devonian fish large, abundant, and highly organized in some cases. [c]Placoderms and some Elasmobranchs first became conspicuous. [d]Ganoids most prominent between the Devonian and Jurassic. [e]Tele-

osts most prominent between the base of the Cretaceous and the present. [f]The very earliest fossil fish, (Q. J. G. S. XLI., p. 48), probably allied to modern Cestraciont Sharks. [g]The Chimeroids.* [h]The Ganoids. [i]The Crossopterygidae. [j]Dipterus. [k]Holoptychius. [l]Ctenodont teeth. [m]The Chondrosteidae. [n]The Cephalospidae. [o]The Placoderms. [p]Pterichthys. [q]Dinichthys.

131. Devonian Plants: Classification of Fossil Plants and their range in the Paleozoic. (For general classification see Lesquereux, Principles of Paleozoic Botany, 13th Geol. Rep't of Indiana 1884; also, Zittel, Handbuch d. Pal. II., 1879–84).

132. Reasons for recognizing a special classification for the botany of fossils, and its necessity for the general treatment possible in these lectures.

133. Lesquereux estimates 6,000 fossil species, 150,000 living. Not over 50 species to square mile in the United States; 140 to 200 species seen in some single coal beds.

134. Four epochs of successive development: 1. Reign of Thallasophites, Silurian; 2. of Vascular Cryptograms, Devonian—Carboniferous—Permian; 3. of Gymnosperms, mid-Permian—Jura; of Angiosperms, Cretaceous—recent.

135. Devonian Floras:

[a]Algae, Uphantaenia, Dictyophyton, Spirophyton. [b]Acrogens; (1) Equisetacea, (Calamites, Asteriophyllites, Annularia, Sphenophyllum); (2) Ferns, (Shimper's Brongniart's classification of fossil ferns): Neuropterideae, Adiantideae, Sphenopterideae, Pecopterideae; (3) Lycopodiaceae: Lepidodendron, Lycopodites, Ulodendron, Knorria, Sigillaria, Stigmaria. [c]Prototaxites. Conifers. [e]Cycads, (? in Devonian).

136. Insecta:

[a]Centipedes. [b]Spiders. [c]Scorpions (in the Silurian also).

137. [a]Tribes of animals rarely seen above the Devonian: Cystids, Trilobites, Orthoceras, Halysites, Favositidae, Chaetetes.

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*Note.—The mention of a family or generic name in this synopsis, indicates the description and illustration of the essential characters of and the more important secondary characters which furnish specific differentia for the genus.

[b]Among Brachiopods, Orthis, Strophomena and their allied genera rarely seen above the Paleozoic.

138. Conspicuous features of [a]the Devonian Fauna are Spirifera and Orthis, in association with Productus and Terebratula, Goniatites, Placoderm Fish; and of [b]the Flora, Psilophyton and an occasional Lepidodendron.

139. Dawson's conclusions from the study of Devonian Plants.

V, THE CARBONIFEROUS.

140. [a]The nature of the transition from the Devonian. [b]The general order of the series of deposits. [c]Two groups of deposits with distinct character to their fossils. [d]Sub-carboniferous or Lower Carboniferous. [e]Carboniferous proper or Coal measures. [f]Permian.

141. The marine fauna of the Carboniferous was conspicuous for Crinoids, certain corals, a few genera of Brachiopods.

142. Characteristic features of the fauna: Protozoa; Fusulina, Nummulina, Saccamina.

143. Corals: (1) Rugosa and Tabulata rare; (2) Lithostrontion, Pailipsastrea and Lonsdaleia characteristic; (3) Zaphrentis, Cyathophyllum and Amplex occasional.

143. Fenestellidae (Archimedes).

144. Echinoderms: (1) Melonites, (2) Archaeocidaris, (3) Blastoids, (4) Crinoids,—Platycrinus, Actinocrinus, Cyathocrinus, Poteriocrinus, Forbesiocrinus. (Three hundred and fifty species of Crinoids recorded from the Burlington limestone, Iowa.)

145. Brachiopods: Productus, Spirifera, Terebratula, Rhynconella. the prominent genera.

146. Mollusca:

[a]Prominent Lamellibranchs were Aviculopecten, Leda, Nucula, Conocardium, Modiola. [b]Common Gasteropods were Natica, Pleurotomaria, Loxomena, Euomphalus. Bellerophon was frequent. [c]Goniatites conspicuous among Cephalopods.

147. Crustacea:

[a]Trilobites, rare and small, few genera. Griffithides and Phillipsia the main genera. [b]Ostracoids—Beyrichia, Leperditia, etc. [c]Entomostraca—Phyllopods, Eurypterids, and a few Xipho-

sura. [d]The higher Crustacea represented by the macruran Anthrapalaemon.

148. Vertebrates :

[a]Sharks—cestraciont and hybodont. [b]Ganoids less conspicuous. [c]A prominent feature, the general absence of the Placoderms. [d]Sauropus, regarded as tracks, the earliest trace of an Amphibian.

149. Special flora of the coal measures :

[a]The character of the deposits. [b]Principal types—Equisetacea, Lycopodiacea and Ferns ; Conifers appear but are rare.

150. Permian flora adds the Conifers and Cycads as prominent features.

151. Fauna associated with the Carboniferous flora.

[a]Fresh water and land Mollusca,– Pupa, Anthracosia. [b]Scorpions, Myriapods, Neuroptera, Orthoptera. [c]Fish—Ganoids and Selachians. [d]Reptiles — labyrinthodont Amphibians and Lacertilia (Eosaurus).

152. Permian, some new features in the fauna and flora :

[a]Protosaurus, a thecodont reptile ; [b]Walchia, Psaronius ; [c]Annularia and Conifers prominent : Conifers (Dadoxylon, Ullmannia, Pinites) ; [d]Sigillarids rare ; [e]no Goniatites.

153. Conclusions. (See Dana's Manual, pp. 382–389.)

VI, VII, VIII, MESOZOIC.

154. The Paleozoic-Mesozoic line not sharply defined in marine faunas.

155. Many prominent paleozoic genera cease to be conspicuous, are rarely, and in some cases never seen again. (See as examples Lepidodendron, Sigillaria, Calamities, the Trilobites, Graptolites, Cystidians, Goniatites, the genus Productus, Tabulate and Rugose Corals, the Placoderms, and the genus Orthoceras.)

156. The Terebratulids and the Rhynchonellids are the prominent families of Brachiopods.

157. The old type of Crinoids—Paleocrinoidea—ceases.

158. A few marine genera extend from the Paleozoic to recent time.

159. Relative length and importance of the subdivisions of the Mesozoic,—Triassic, Jurassic, Cretaceous.

160. Mesozoic Protozoa—Orbitolina, Nummulinidae, Globigerina, Textularia. (See also Diatoms and Desmids.)

161. The nature of green-sands.

162. Coelenterata :

[a]Sponges and [b]Corals, (Actinozoa)—Astraeidae, Fungidae, Aporosa, Madrepores—Perforata.

163. Echinodermata :

[a]Crinoids—Encrinus. Pentacrinus, etc. The Pychnocrinoidea of Pictet. [b]Starfish. [c]Echinids, regular, as Cidaris ; irregular as Spatangus ; sessil forms, Marsupites, and free Saccosoma, like the Comatulas.

164. Brachiopoda were restricted, with few exceptions, to the families of the Terebratulas, Rhynchonellas, Discinas, Lingulas, and Cranias.

165. The prominent Lamellibranch families : Trigonidae, Ostreidae,—genera, Ostrea, Gryphea, Exogyra.

166. The Hippuritidae, (Rudistes, etc.).

167. Gastropods—all except a very few families were represented before the close of the Mesozoic.

168. Cephalopods—first order, Tetrabranchiata :

[a]First sub-order, Nautiloidea, mainly Paleozoic. Only two families pass the limit of the Paleozoic, viz. : Orthoceratidae, (gen. Orthoceras), and Nautiidae (genera Nautilus and Aturia). [b]Orthoceras known in the Mesozoic in only a single region, —the St. Cassian beds—but is there associated with the Ammonoidea. [c]Nautilus reaches its culmination in the Mesozoic.

169. Second sub-order, Ammonoidea, mainly Mesozoic.

170. Of the Dibranchiata—second order—the first sub-order, Decapoda, was mainly Mesozoic. One family, the Sepiophora, did not appear till the Tertiary.

171. The second sub-order, Octopoda—example Argonauta—left no traces earlier than the middle Tertiary.

172. Of the Ammonoidea a few families of [a]the Prosiphonata have been represented by species from the deposits, called Permo-Carboniferous in India, (the salt-range group, see Waagen's Report,) and [b]the two retrosiphonate families—Clymenia and Goniatites—are confined to the upper Paleozoic, but [c]the great mass of species and genera are Mesozoic.

173. Second order, Dibranchiata :

[a]Of the sub-order, Decapods, all the families, except Sepiophora, began before the close of the Mesozoic. [b]The sub-order Octopoda—Argonauta is not recognized below the later Tertiary.

174. The various characters adopted by different authors as criteria of classification, such as the position of the siphon, the degrees of coiling or curvature of the shell, the sutures, etc., their relative values, and their relation to theories of interpretation of the Ammonites.

175. The necessity, in studying the history of organisms, of taking note of the degree of plasticity the characters exhibit when found under the same conditions, and at a single stage.

176. Classification and range of the Dibranchiata.

177. The Phragmophora (Belemites, etc.).

178. Arthropoda of the Mesozoic :

[a]Lobsters. [b]Shrimps. [c]Crabs. [d]Beetles. [e]Butterflies. [f]Grasshoppers.

179. The cases of the Scorpion lately found in the Silurian, a Trilobite in the Mesozoic and a Cystid dredged from the deep sea, suggestive of caution in trusting negative evidence as to exact limits of initiation or extinction of groups of organisms.

180. Reptiles :

[a]Huxley's Classification. [b]Labyrinthodonts, placed with Amphibians in the province Ichthyopsida. [c]Sauropsida—a province including Birds and Reptiles. [d]Chelonia. [e]Plesiosauria. [f]Lacertilia. [g]Ophidia. [h]Ichthyosauria. [i]Crocodilia. [j]Dicynodontia. [k]Ornithoscelida. [l]Pterosauria.

181. Characters important in classification and history :

[a]Of the vertebrae,—amphicoelian, opisthocoelian, and procoelian. [b]Of the teeth—labyrinthodont, pleurodont, acrodont, thecodont, maxillary, palatine, pterygoid and vomerine teeth. [c]Of the jaw—(1) each ramus a single bone, (2) or of several bones anteriorly united by anchylosis, ligament or muscle, (3) joint in middle of ramus, (4) proximal articulation, by quadrate bone, or direct, (5) the occipital condyle, single in the Saurosida, two in Amphibia.

182. For each order—the prominent characters, an age of initiation, an age of culmination, an age of extinction.

183. Avian Reptiles, and Birds :

[a]Triassic—Jurassic, Avian Reptiles, (1) Ornithoscelida—Dinosauria, Compsognatha ; (2) Pterosauria—Pterodactylus, Dimorphodon, Ramphorhynchus and Pteranodon (Cret.), Archaeapteryx. [b]Cretaceous—Reptilian Birds and Birds ; (1) Odontornithes—Hesperornis, Ichthyornis and (2) a few genera of the swimming (Natatores), and of the wading (Gallatores), Carinatae. [c]Tertiary—with the Tertiary the first initiation of the other orders of Carinatae—the Rassores, the Scansores, the Insessores, the Raptores, as well as most of the families of the Natatores and Grallatores, also the non-flying birds—the Ratitae.

184. Ornithoscelida :

[a]Tracks in Triassic regarded as Dinosaurian. [b]Bird-like characters seen in the anterior extension of the Ilium, the slender and backward prolonged Ischium, and in several characters of the hind limb bones.

Toothed Birds :

185. Odontopteryx, only serrated bill, no true teeth.

186. Hesperornis, lower jaw fully toothed, upper jaw, back part toothed, front part bill, teeth in sockets.

187. Ichthyornis, carinated sternum, amphicoelian vertebrae. (Pteranodon, a flying reptile,—Cretaceous—with bill, no teeth. See 191.)

Flying Reptiles :

188. Pterosauria, teeth and wings, "patagium" as in bats, pneumatic cavities in bones as birds.

189. Pterodactylus, fully toothed.

190. Rhamphorhynchus, only back part toothed.

191. Pteranodon, no teeth. (See 187.)

192. Birds ; class characters and classifications.

193. Archaeopteryx.

104. Odontornithes.

195. Ratitae. (? Dinornis, etc.)

196. Carinatae :

[a]Natatores—Albatross, Swans, Cormorants, etc. [b]Gral-

latores—Sandpipers, Rails. The other orders, [c]Rasores, [d]Scansores, [e]Insessores, and [f]Raptores did not appear till the Tertiary.

IX, THE TERTIARY.

197. Mammals, [a]except Marsupials, begin in Cenozoic. [b]Essential characters of the class. [c]Ordinal characters, i. e., differentia seen in various modes (1) of birth and early care of young, (2) of progression,—feet and limbs, (3) of defense and attack,—teeth and horns. [d]Significance of milk secretion ; of hair ; importance of characters of the occipital condyle. [e]Study of the chart of classification and history of Mammals.

198. Monotremes—bird-like in some points of structure, and in function of ovapositing—first trace of in Post Pliocene.

199. Marsupials—the first mammals, appear in early Trias, prominent in Mesozoic ; significance of Marsupium.

200. Cetaceans, (Zeuglodon) marine.

201. Ungulata, both Perissodactyls and Artiodactyls, first appear in Eocene, and with modern families of Rhinoceros, Tapir, Horse, Swine, Musk-deer ; the other families nearly all represented before Pliocene.

202. Dinoceras, etc.

203. Proboscidians, the three types appear in Miocene.

204. Carnivora ; first in Eocene, the perfect cats among the first ; almost all its families in Miocene.

205. Before the close of the Miocene all the orders of Mammals except Man have appeared.

206. Review of the history of Organisms :

[a]Progress in organic structure coördinate with the geological development of the environment, [b]early inhabitants purely marine, [c]the presence of coasts, of fresh water from lands, of dry land, of air, each recorded in an increased complexity of structure, and a fuller specialization of organs for special functions.

207. The law of plasticity, and the consequent adaptability of organisms to environment.

208. The law of heredity, and the perpetuation by generation of ancestral characters.

209. Food and population, the survival of the fittest.

210. Death the natural result of performed function.

211. Gradual evolution of new forms by intensification of varietal peculiarities.

212. Initiation of new types of organisms.

213. All Nature, inorganic and organic, studied historically, points to an origin and a Cause.